

Welcome to the Land Cover/Biology Investigation

Introducing the Big Picture



The type and amount of land cover in an area are important characteristics from the standpoint of understanding Earth systems and how they operate. Land cover influences the reflection of solar radiation from the land surface. This in turn influences the heating of the atmosphere, local and regional climatic patterns, and the kinds of living things that are associated with each cover type. Variations in type and amount of land cover influence the way materials such as water, carbon, nitrogen, and sulfur are cycled between the soils, plants and the atmosphere. An area of research known as Earth systems science has developed over the last decade. This discipline studies the interactions among the various Earth systems (atmosphere, hydrosphere, biosphere, geosphere, etc.). GLOBE students will be mapping land cover and providing ground observations which will advance the research of Earth systems scientists. For an overview of global imaging and other observations, see A Global Viewpoint in the Toolkit.

Mapping will take the form of distinguishing the types, or classes, of cover on the surface. There are many systems for classifying land use. For GLOBE we have adapted the international system used by the United Nations. See Tables 4-1 and 4-2. We call this the Modified UNESCO Classification (MUC) system.

Identification of the various land cover classes in an area can be done in a number of ways. Satellite datasets are common sources of images of land surface characteristics used to make land cover maps. However, simply examining an image without some specific knowledge of the area involved may reveal little about what the actual land cover is. The best and most accurate source of information on the kinds of land cover imaged comes from visiting the site on the ground and conducting a detailed assessment of its characteristics. The data that you and your students gather from such visits constitute a very important source of information regarding the actual ground conditions in the dominant land cover types within your 15 km X 15 km GLOBE Study Site. In particular, the detailed data acquired from both the 30m X 30m Biology Study Site and the 90m X 90m Land Cover Study Sites will contribute to a better understanding of the biomass, land cover, and the amount of photosynthesis taking place in your part of the world.

Natural vegetation is so important to the myriad processes and cycles of interest to Earth systems scientists that you will be conducting several detailed measurements in those ground sites which are dominated by vegetation. These measurements are referred to as “biometry” and they quantify the size and extent of the plants in your site(s). This is important information for a variety of reasons:

- 1) Although humans have extensively modified and replaced natural vegetation, most of the Earth's land surface is still covered by the naturally vegetated ecosystems which evolved in response to the geographical and climatic conditions present. The type and nature of the vegetation present therefore tells us a great deal about other environmental variables such as rainfall or temperature.
- 2) Terrestrial vegetation is a major component of the large “system” we call the Earth. Plants absorb and cycle nutrients - carbon dioxide, nitrogen, sulfur and phosphorus from the atmosphere and soil. They absorb water from the soil, incorporating it into their tissues, and “transpiring” some of



it to the atmosphere. Plants also form the basic foundation of the food chains which support other life forms.



- 3) Vegetation can be a sensitive indicator of change in local or regional environments. Human-induced changes in vegetation affect not only the plants themselves, but all the important cycles of nutrients and water in which vegetation plays so important a role. Subtle changes in climate or other environmental factors may reveal themselves first as changes in the type or growth of local vegetation.
- 4) Because of the importance of vegetation, the land-oriented satellite sensors you will use for mapping are designed specifically to identify and discriminate various kinds of vegetation. In addition, recent research has shown that satellite data are sensitive to the amount and health of many types of vegetation, but ground observations are needed to quantify and calibrate these relationships.

For all of these reasons, Earth systems scientists are eager to have your maps, and your detailed biometric observations of naturally vegetated ground sites. They will tell us how important factors may be changing over time, how sensitive or resilient ecosystems are in the face of environmental change, and improve our ability to interpret the satellite imagery we rely on to monitor large areas of the Earth's surface.



Your field observations fill a major gap in scientists' ability to understand our planet because it is virtually impossible for us to visit the number of sites to collect all the data that we need. There is simply not enough time, money, or energy to get to enough sites. Therefore, the use of remotely sensed data (information collected from photography and satellite imagery) is critical to acquiring all the knowledge we need to understand the Earth as an ecosystem. Remotely sensed data can quickly and efficiently cover the entire Earth. As a GLOBE school you are given satellite imagery of a relatively large area compared to your school size. It would be very time-consuming and difficult for you to visit every area in your 15 km x 15 km GLOBE Study Site and yet one satellite image easily covers your area. Using the tools that are described in this protocol you will generate a land cover map of your entire GLOBE Study Site, either by manual interpretation or use of a computer program called MultiSpec. From this land cover map that uses the MUC classification scheme, you will learn a lot about the area around your school.



Does this land cover map then replace the need to visit sites on the ground? Absolutely not! The ground data collection is critical to the best use of the remotely sensed information. In order to be able to make the land cover map from the remotely sensed data, it is necessary to have visited some areas on the ground so that you know what things are on the satellite image. Without this ground data it would be impossible to effectively make a land cover map from the satellite imagery. A second use of the ground data is for verification of the land cover map. A vital consideration for every scientist is the confidence that she or he can place in their methodology. Often this confidence is based on some statistical measure. Such is the case in evaluating land cover maps generated from remotely sensed data. In order to use the map and have some confidence in the decisions made, it is critical that the map be tested to see how good it is. This validation process is performed by comparing sample areas on the map with actual site visits on the ground. This comparison is then summarized in a table, called a difference or error matrix, which shows how well the land cover map represents what is really on the ground. Without ground data it would not be possible to generate land cover maps from remotely sensed data nor could we validate them once they were created.



GLOBE Student Data as Input to Models

Research scientists at the University of New Hampshire (UNH) will incorporate GLOBE student data into models used in their on-going research projects. The long-term goal of their research projects is to understand the primary biogeochemical cycles of Planet Earth. The primary cycles to be studied in this project include the carbon, sulfur, nitrogen and water cycles. We will develop methods for using student-



derived data for the purpose of calibrating and validating models developed as part of the study of biogeochemical cycles.

The overall strategy used in the UNH project is to develop and use models¹ to study how the element cycles function, both in natural systems where perturbations in the environment are produced primarily by climate variability, and in systems where disturbances induced by human activities have modified exchanges of carbon, sulfur nitrogen and water within the atmosphere/hydrosphere/biosphere. One example of a model being developed under this research activity is the PnET carbon flux model. The PnET model has been designed to predict both photosynthesis (Pn) and evapotranspiration (ET) for a given type of forested cover. The GLOBE measurements used as inputs for PnET include some that are made for the land cover protocol as well as several from other protocols. They include;

- Land cover class (MUC)
- Maximum/minimum air temperature throughout the growing season.
- Precipitation throughout the growing season.
- Tree circumference at a height of 1.35 meters and how it changes over time.
- Soil moisture throughout the growing season.

Other data are included, and the model is run using a set of initial conditions (e.g. forest type) and a time series of temperature, precipitation and soil moisture to simulate actual conditions. The model output of wood production over time can be compared with measured increases in tree size using circumference

We want you and your students to become “partners” in our Earth Systems research. The essence of a partnership is that each of the participants bring unique strengths which make the collaboration stronger.

¹ **Why Scientists Use Models**

As children, we all played with toys. Toys are generally physical models which represent items that are important in the adult world, that are not available to children. Baby dolls, toy cars and trucks, stuffed animals, etc., are all examples of physical models that allowed us to use our imaginations to explore and better understand our childhood world. Conceptual or mathematical models are a tool used by scientists to explore and better understand processes or phenomena in the real world. There are several reasons why models are used.

One of the reasons is that models allow scientists to evaluate processes or phenomena that would be difficult to study in any other way. The study of the processes of photosynthesis and evapotranspiration is such an example. In both cases, the rate of each process is dependent on gas exchange at the stomates in leaves. Open stomates allow exchange of CO₂, O₂ and water vapor, while closed stomates dramatically reduce such gas exchange. Measurement of small amounts of gas exchanged by a single leaf is possible using a device known as an “infrared gas analyzer,” but it is time consuming and only allows one leaf to be analyzed at a time. However, if light conditions are known (full sunlight causes stomates to open, while cloudy conditions lead to closed stomates in many plants), and the amount of recent rainfall (governs the availability of water needed to open stomates) and maximum temperature (temperature influences the rate of diffusion of these gasses in or out of the open stomates) are known, a model can be developed which predicts gas exchange rates. If the amount of foliage is known, the photosynthetic rate and evapotranspiration rate for entire trees and/or forests can be modeled.

Another reason for using models is that in order to make a model which works well (the predicted results compare well with actual measured results) the developer of the model must really understand the process being modeled. Developing a model forces scientists to consider all of the input variables (such as CO₂, O₂ and water vapor, as well as temperature, available water, duration and intensity of sunlight, etc.) and the interrelationships among these variables. As a part of the process of developing a model, a more thorough understanding of the process being modeled results.

A third reason for using models relates to being able to modify the input parameters in order to predict realistic changes in output. This is an especially valuable aspect of using models when actual experimental manipulation of input variables is either impractical or impossible. Using the example of photosynthesis and evapotranspiration, a model allows scientists to study the effects of increasing atmospheric CO₂ and temperature on both photosynthetic activity (primary production) and return of water vapor (transpiration) to the atmosphere for forested sites. Such an experiment would be impractical to do in “real life.”



Your contribution is the intimate knowledge you have, and can obtain, of your local area. Our role as scientists is to place that knowledge into the larger context of understanding our planet. Only by working together can we hope to gather both the “details” and the “big picture” concerning the Earth system.

Student Learning Goals

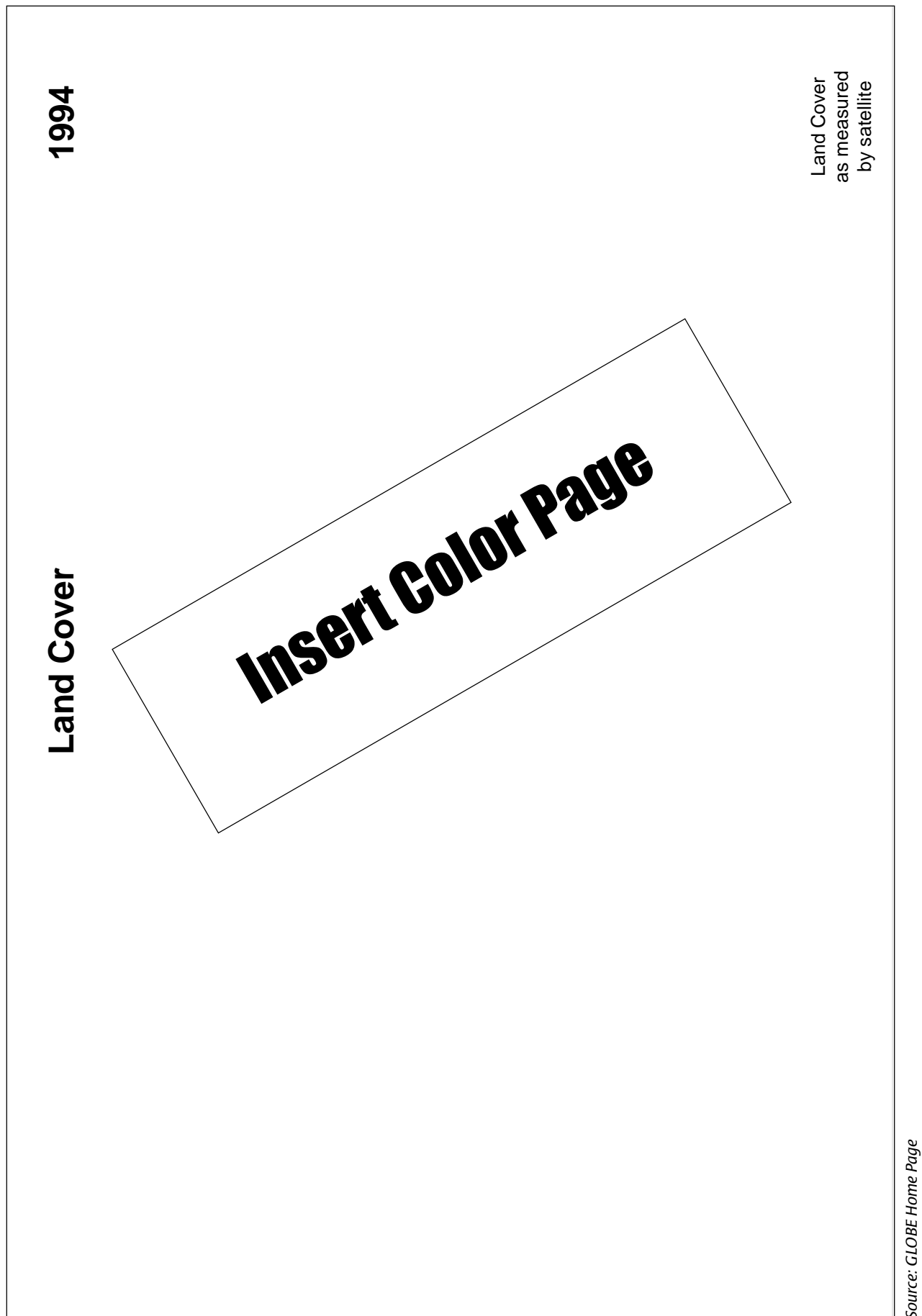


There are two overarching concepts for this investigation. The first is “systems,” examined by the biometry/phenology protocols. The sub-concepts involved are productivity, boundaries, inputs, outputs, cycles (seasons, feedback loops). Some of our processes are representative sampling, indirect/direct measurements, classification (generalizations and choices), and drawing conclusions based upon evidence

The second overarching concept is “models,” and will be used for the remote sensing/accuracy assessment protocols. Sub-concepts are representations of reality, symbolic representation, scale, perspectives, habitat, land use changes, and habitat fragmentation. Some of our processes are mapping, modeling, and validation.



Figure 4-1: Global Land Cover



Source: GLOBE Home Page